INNOVATIVE UNDERGROUND DISTRIBUTION CABINET FOR LOW VOLTAGE NETWORK

Nuno SANTOS
EDP Distribuição – Portugal
nunoloureiro.santos@edp.pt

Miguel LAGARTO
EDP Distribuição – Portugal
miguel.lagarto@edp.pt

Carlos RODRIGUES
EDP Distribuição – Portugal
carlosadriano.rodrigues@edp.pt

ABSTRACT

In order to respond to political constrains in the city of Lisbon, EDP Distribuição has developed an underground distribution cabinet prototype, made in Portugal. This paper addresses the issue by exposing the problem and presenting the solution developed. This article starts with a contextualization of the current paradigm and the problem identification, followed by the study and development process of the solution. At the end of the paper it is presented the analysis of the prototype's installation and operation. The solution proposed mitigate the problem and prove the concept, resulting in a viable alternative for low voltage networks in urban city centers.

Keywords – underground distribution cabinet, low voltage network, network components.

INTRODUCTION

The low voltage distribution cabinets represent a fundamental infrastructure for the underground electric distribution of urban centers. The flip side to this kind of infrastructure is the space occupation and the visual pollution. Due to the visual impact of low voltage distribution cabinets on Lisbon's historic center, the City Hall challenged EDP Distribuição to find a solution that could mitigate this impact on the architecture of the city. Furthermore, by freeing us space from sidewalks, we are improving people's mobility, also resulting in an environmentally friendly solution.

Figure 1. Example of the visual impact of distribution cabinets in Lisbon's historic centre.

In order to attend to this request EDP Distribuição started a project aiming to find a solution for this problem, without compromising safety regulations and grid operation.

In new urban areas a traditional solution is to embed the cabinets into a building's facade (wall-mounted recessed type cabinets) but, in the case of historic buildings, the embeddedness could become problematic as it could risk building's structure or the importance of the building's architecture.

It was made a decision to develop an underground cabinet for replacing the existing ones in the nearby area.

DESIGN AND CONSTRUCTION

Main concerns

In the development of the prototype, there was special concern on the following fundamental subjects:

- Safety
- Overall dimensions
- Casing sealing
- Air ventilation
- Protection against corrosion
- Mechanical design
- Installation conditions
- Costs

Constitution of the underground cabinet

The underground cabinet consists of two main parts:

- Distribution cable cabinet;
- Concrete casing (enclosure).

The distribution cable cabinet complies with EDP Distribuição specification, DMA-C62-801/N [1], for the X-type standard cabinet, except for the design of the fuse-rails (see section below relating safety).

The concrete casing integrates two separate compartments: 1) Busbar compartment: intended to receive the connection of the external conductors, also assuring electrical connection with the distribution cable cabinet circuits through the fixed-flexible conductors; 2) Cabinet compartment: space intended to accommodate the cable distribution cabinet (in a horizontal position).

Both compartments can open separately.

The cabinet compartment is designed to operate in two positions: closed (horizontal position) or opened (vertical position). In the opened position, the cabinet can be operated identically to ground-mounted surface cabinets.

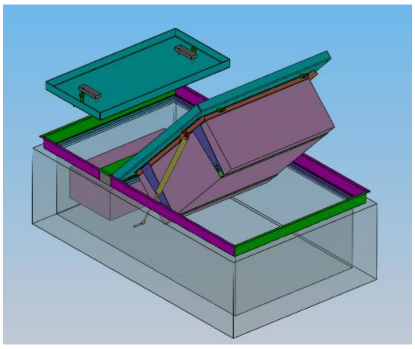

Figure 2. Design of *EDP Distribuição* underground cabinet prototype.

Safety

People's safety was a major concern in the development of the prototype and led to a set of decisions, as follows.

Regarding operation, it was decided to equip the distribution cabinet with three pole fuse-switch-disconnectors of vertical design and manual dependent operation, pole by pole, since most of the defaults, about 90%, are phase-neutral defaults. The fuse-rails assure a degree of protection IP2X (suitable for protection for fingers up to 80 mm long) and meet the utilization category AC22B (suitable for breaking and making mixed resistive and inductive loads, including low overloads), according to EDP Distribuição specification, DMA-C63-202/N [2]. This option intends to provide additional safety to the operator and faster manoeuvre, not sparing however the adoption of additional safety measures namely by the use of Individual Protective Equipment (IPE) when operating, in particular helmet with visor and electrical and mechanical protection gloves.

For protecting people against indirect contacts, as provided for in national regulation, all extraneous conductive parts are connected to the neutral and these directly to the earth. In this way, any insulation failure occurring between live parts and extraneous conductive parts of the cabinet will result in a phase-neutral default, which will be promptly eliminated by a fuse-link located in the corresponding upstream circuit, in a time interval not exceeding 5 seconds.

Additionally, it was designed a foot stand in insulated material, of fibreglass reinforced polyester (FRP), removable, which will enable the operator manoeuvring in total safety the vertical fuse-rails, standing above ground level, as if operating a standard ground-mounted surface distribution cabinet.

The lifting of the distribution cabinet above ground is ensured by hydraulic pistons, which allow the rotation of the cabinet (joined together with the lid), from a horizontal to a vertical position. For security reasons and due to the weight of the lid, it was considered a n-1 redundancy, once each hydraulic piston is sufficient to support the total weight of the set consisting of the lid and the cabinet. On the other hand, a vertical position of the referred set was sought in order to get a situation of almost equilibrium of its mass center, thus reducing to the minimum the effort exercised on the shock absorbers, being the cabinet in the vertical position (opened position).

Figure 3. Cabinet compartment in the open position.

The arrangement of the busbar in the compartment and the position of the cables entries were thought to facilitate connections and future maintenance operations, aiming the largest possible air clearances based on the available internal space. The (live) busbar is enclosed by an insulated barrier of polycarbonate transparent material, which prevents direct contacts with live parts when the lid is in the opened position. Initially it was considered the use of insulated devices (terminal blocks complying with IEC 60947-7-1) with a degree of protection IP2X, to be placed side by side, with the function of establishing the connection between the external conductors and the flexible fixed conductors, which are in turn connected to circuits of the distribution cabinet. This option would have made it unnecessary to use live busbar. However, strangely, this was not possible to apply, because no products were found on the market that could meet the intended purpose.

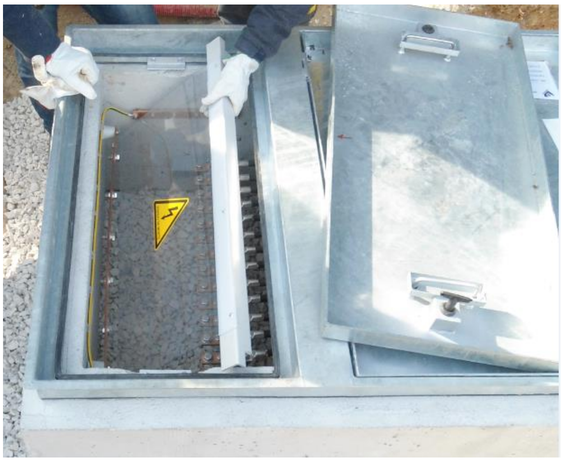

Figure 4. Cabinet busbar compartment.

Overall dimensions

Desirably, the cabinet should be as small as possible in order to solve some situations where it is not possible to place electrical equipment on the building walls or on the sidewalks, above ground level, due to their small width (especially, in historical areas). On the other hand, as part of the solution, it was decided to incorporate an already standardized and qualified (of ground mounting) cabinet in order to achieve a good performance and to facilitate future maintenance actions. However, the opted solution required that dimensions of the underground cabinet would have to be higher than those of the standardized cabinet for direct installation on the ground.

The dimensions of the busbar compartment were defined to allow an easy and safe connection of the external conductors.

Taking all these premises into account, the prototype was developed with an overall outer dimensions of 1,8m x 1,0m x 0,5m (length x width x height).

Casing sealing

The casing was developed with an opened bottom, basically because no technical suitable solution was found for the heat dissipation issue, in the case of a fully hermetic closing system.

However, this solution is only suitable for locations with low groundwater level, condition assumed, concerning the selection of sites for the cabinet installation.

Despite this particularity, casing ensures sealing from external outer environment (above ground level), once closed, except on the side vents, which were conceived to allow air ventilation.

Air ventilation

Side vents were placed on the outside of the casing to allow air circulation by natural convection. Air circulation is intended to prevent formation of condensation due to soil moisture, as well to enable effective dissipation of the heat produced by fuse-links (the maximum power dissipation in normal service conditions is 135W), thus avoiding excessive heating of metal parts which may lead to deformation and/or deterioration of adjacent insulated parts.

Openings were designed, on one hand, to prevent entry of trash inside the casing, and on the other hand, to conduct run-off of rains to the soil through casing interior side faces (away from switchgear and equipment).

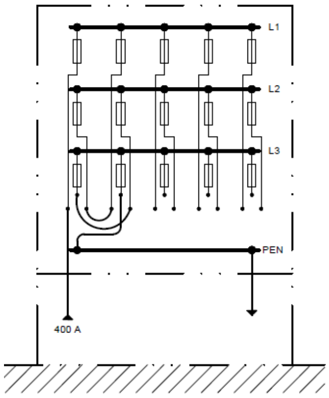

Figure 5. Power dissipation test fot X-Type distribution cabinet, from *EDP Distribuição* regulation's DMA-C62-801/N [1].

Protection against corrosion

All steel metal parts are protected by a layer of zinc coating with a minimum thickness according to the recommendations of ISO 1461 standard, by the process of hot-dip galvanization.

All screws, bolts, fasteners, nuts and washers are made of stainless steel grade A2-70.

Mechanical design

Although it is planned to install the cabinet in sidewalks, it was however considered the possibility of significant loads (road vehicles) circulate over the cabinet or be parked on it. Taking this into account, the cabinet was designed to withstand a stationary vertical load equivalent to the weight of a car.

No specific requirements were made to the concrete casing, of standard class C 25/30, although it must withstand, without any damages, the lateral pressure forces applied by the surrounded terrain (below ground level).

Installation conditions

Since the casing was designed with an opened bottom, it was considered that the installation should be made over thin layers of sand and gravel, allowing an efficient water draining for the purpose of keeping the soil surface dry, under the underground cabinet, and avoiding the formation of condensation due to soil moisture, particularly in the case of small (electric) loads (condition of low heat dissipation).

Also due to the opened design of the casing, the underground cabinet is intended to be installed at places having low waterground level.

The overall dimensions do not allow the installation of the new solution in areas with limited space such as old and historic zones.

Costs

In the design of the prototype, there has been concern about its cost, considering the Global Life Cycle of the asset - i.e., considering all the respective phases of design, conception, acquisition, installation, operation and maintenance -, seeking a competitive solution without yet compromising the required safety and reliability requirements intended for the equipment.

Past experiences with other prototypes, best practices and informed input from the various stakeholders, from design to maintenance, have been taken into account.

A partnership with a local manufacturer was established, thereby promoting the development of the domestic industry and resulting in synergy gains with the accumulated knowledge of this partner in other areas of industry.

ASSEMBLY AND OPERATION

Assembly the prototype

A ground-mounted (superface) type distribution cabinet was chosen to be replaced, located in an area with ample walk space and without any interference from other infrastructures.

The site was studied jointly with the Lisbon City Hall and it is located in Alameda Cardeal Cerejeira, next to the Parque Eduardo VII, one of the largest parks in the center of Lisbon.

One of the main factors for choosing the location, besides the visual impact in one of the busiest areas of the city, was that the location has a low water table which allows a safeguard for the flood of the equipment.

Figure 6. Photo of the installation selected site

In the area in front of the existing distribution cabinet, an excavation was necessary to allow the placing of the underground cabinet and the execution of the electrical connections. The excavation had the dimensions of 3,5m x 2m x 0,8m (length x width x depth).

It was placed a layer of gravel of 0,2 meters under the cabinet, to level the ground and allow drainage of water that may enter the compartment.

Figure 7. Installation of the underground cabinet

The underground cabinet was transported to the working area in a common truck with an appropriate crane.

The electrical connections were made in tension so that the works had no impact on the power supply at the zone delivery points.

The conductors of the external circuits were connected to the busbar, being prepared with bimetallic (aluminum-copper) terminals in accordance with the EDP Distribuição normative document DMA-C33-850/N [3].

The connection between the neutral and the earth electrode terminal was made with an isolated VV type cable with a cross section (of the copper conductor) of 35 mm2.

The underground cabinet is prepared to include, on the top of the shell, material equal to floor where it is inserted. In this case of the prototype the finishing was done with Portuguese traditional flooring.

The installation went well and without any constraints.

Figure 8. Cabinet after installation

Operation and maintenance

The use of a standardized cabinet within the underground cabinet allows a great advantage in the maintenance of the equipment, since in case of breakdown the cabinet can be replaced by an identical cabinet in storage.

After opening the cabinet compartment the operator have at his disposal a sturdy platform for placement in the upper part of the compartment, which allows the operator to remain outside the concrete structure at ground level during the execution of maneuvers in the cabinet, being this an advantage regarding safety.

CONCLUSIONS

Results

As planned, the prototype was installed successfully by the end of 2016, and it is in full operation. This way, the project achieved the expected results, complying with the stipulated budget.

Benefits regarding costs

The whole project was designed and produced in Portugal with a cost of 80% less than a similar underground cabinet currently operating in Lisbon's electric grid. In an Economy of scale production system, the total technology cost can even more be reduced.

Expectations achieved

With the presented solution EDP Distribuição responds to the identified necessity of City Hall to find a way to improve visual impact of electrical equipment in the architecture of the city, as well to increase people's mobility in sidewalks by eliminating superficial infrastructures.

Also it is expected, as corollary of this development, to have in the future a standard competitive and viable solution for underground cabinets, to be implemented in a national level, allowing to solve similar problems concerning mobility and visual impact.

Future developments

It is intended to monitor the performance of the prototype with the purpose of making future decisions on a standardized solution at national level, on a larger scale.

Figure 9. Visual impact with the traditional cabinet

Figure 10. Friendly environmental solution

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